EVALUATION OF TIME-AVERAGED CERES TOA SW PRODUCT USING CAGEX DATA

Ann B. Carlson* and Takmeng Wong
Atmospheric Sciences Division, Langley Research Center, NASA
Hampton, VA

1. INTRODUCTION

A major component in the analysis of the Earth's radiation budget is the recovery of daily and monthly averaged radiative parameters using non-continuous spatial and temporal measurements from polar orbiting satellites. In this study, the accuracy of the top of atmosphere (TOA) shortwave (SW) temporal interpolation model for the Clouds and the Earth's Radiant Energy System (CERES) is investigated using temporally intensive half-hourly TOA fluxes from the CERES/ARM/GEWEX Experiment (CAGEX) over Oklahoma (Charlock et al., 1996).

2. ANALYSIS

In order to initiate intercomparison between the CAGEX (hereafter referred to as truth) data and the data set that would be collected by the actual CERES instrument, simulated CERES TOA SW flux measurements over the CAGEX region are produced by sub-sampling the truth data set using orbital overpass information (both space and time). The angular distribution models (Suttles et al., 1988) of albedo vs. solar zenith angle for various clear and cloudy backgrounds are then used to interpolate these simulated data sets in time to produce the diurnal, monthly-hourly and monthly mean CERES TOA SW fluxes. CAGEX consists of half-hourly data from 14:09 GMT to 22:39 GMT daily for 26 days in April, 1994. For the purposes of this study solar flux is assumed to be zero beyond the hours of CAGEX measurements.

The CERES ERBE-like monthly SW TOA product is produced by interpolating satellite observations to other times of the day using the diurnal angular distribution models. For days with only one SW flux measurement, the observation is modeled to all daylight hours assuming the cloud classifications remain constant throughout the day (Harrison et al., 1995). For days with more than one measurement, this technique is modified as illustrated in Figure 1. All daylight hours preceding the first measurement of the day and following the last measurement presume constant cloud classification. For hours between the two measurements, total albedo is produced by inversely weighting the two estimates by the time from the hour of interest.

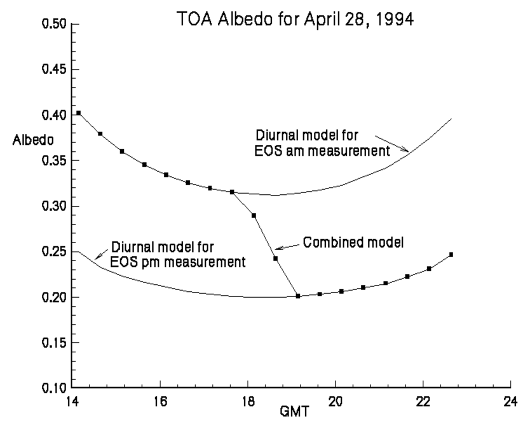

Figure 1. Interpolation of albedo assuming both EOS-AM and EOS-PM measurements.

CERES will use geostationary data to assist in modeling meteorological variations between observation times in an attempt to improve diurnal estimates of SW flux. A rough assessment of the possible improvement in calculated SW flux averages was computed as follows: Accurate CERES measurements of TOA SW flux and cloud cover were assumed available at 3-hourly intervals which correspond to the truth data set at 15:00, 18:00, and 21:00 GMT. An interpolation scheme similar to the above was used to derive a diurnal model of the albedo for the full day and the resulting estimate of TOA SW flux compared to the truth data set.

In Figure 2 estimates of TOA SW flux for April 28 and 29 are compared with the truth (CAGEX) data set. The SW flux estimate based on a single satellite data point (in this case the EOS-PM overpass), combined EOS-AM and EOS-PM observations, and the three-hourly coincidence are shown. On April 28, the improvement by increasing the number of satellite data points in the diurnal modeling is clearly seen for both two and three point coincidences. The April 29 day shows a common problem when EOS-AM and EOS-PM measurements are used. At least for the Oklahoma site of CAGEX, the cloud cover varies more dramatically from early morning to late afternoon, but is often constant near mid-day when both the EOS- AM and PM

* *Corresponding author address:* Ann B. Carlson, Atmospheric Sciences Division, NASA/Langley Research Center, MS 420, Hampton, VA 23681
email <a.b.carlson@larc.nasa.gov>

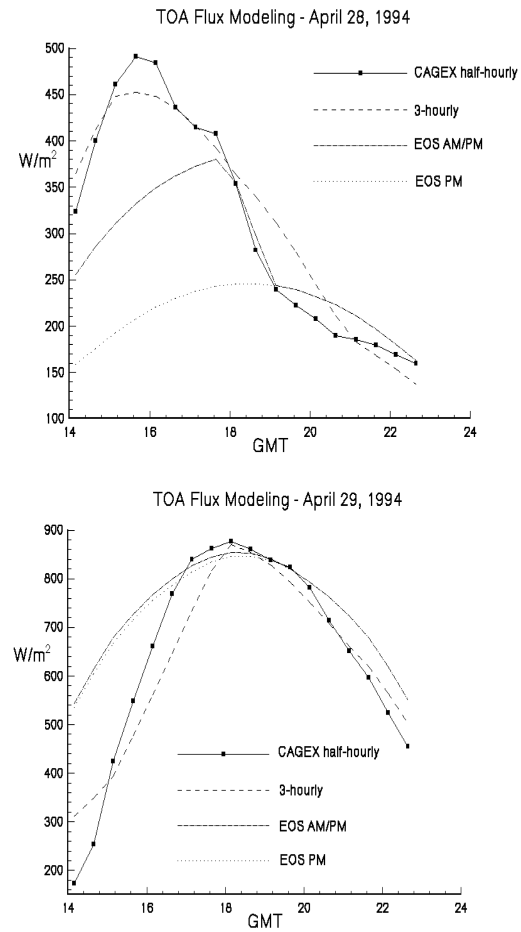

Figure 2. Comparison of diurnal flux estimates for one, two and three coincidence points

measurements are taken. Thus, using both satellite measurements results in little actual improvement in the diurnal model.

The monthly-hourly average for the full 26 day CAGEX data set is shown in Figure 3. The 3-hourly coincidence data does a much better job of approximating the truth data than either the single satellite or combination EOS-AM/PM estimates. Comparisons of the monthly (26-day) mean show an rms error in TOA SW flux of 4.9 W/m^2 for the single satellite estimates, 4.7 W/m^2 for the EOS- the EOS-AM/PM combined estimates, and 1.3 W/m^2 for the three-hourly estimates. The average daily variance was 13, 9 and 3 W/m^2, respectively.

3. CONCLUSION

An intercomparison between the CAGEX April 1994 data set and a simulated CERES data set based on CAGEX has been used to evaluate the temporal interpolation method for the time-averaged CERES TOA SW product. Errors in modeled vs. truth diurnal variation of SW flux arise

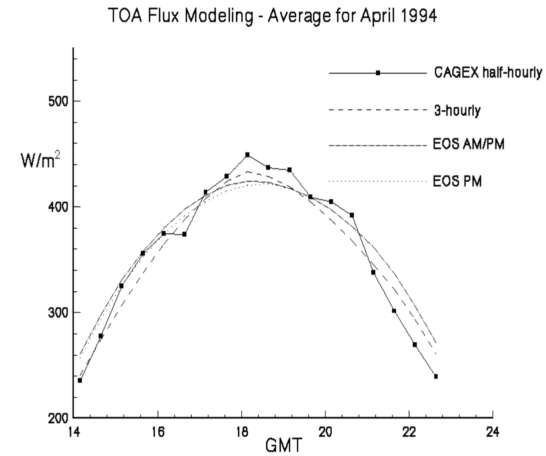

Figure 3. Monthly-hourly average

in part because of temporal changes in cloud type and coverage and may also be associated with inaccuracies in the diurnal angular distribution models. Results show that the monthly mean rms error in TOA SW total-sky flux for the single satellite case is approximately 5 W/m^2, comparable to current CERES uncertainty estimates. Some improvement is realized if data from both EOS-AM and EOS-PM satellites is available, but this improvement is not as dramatic as would be realized if geostationary data were available at evenly spaced 3-hour increments throughout the daylight hours.

4. ACKNOWLEDGEMENTS

The authors are grateful to T. P. Charlock for providing the CAGEX data and to D. F. Young for providing the angular distribution model code.

5. REFERENCES

Charlock, T. P. and Alberta, T. L. 1996: The CERES/ARM/GEWEX Experiment (CAGEX) for the Retrieval of Radiative Fluxes with Satellite Data. *Bulletin of the American Meterological Society,* in press for November. .

Harrison, E. F., Minnis, P., Young, D. F., Gibson, G. G., Donaldson, J. L., and Smith, O. C. 1995: ERBE-Like Averaging to Monthly TOA (Subsystem 3). *Clouds and the Earth's Radiant Energy System (CERES) Algorithm Theoretical Basis Document, Volume II: Geolocation, Calibration, and ERBE-Like Analyses (Subsystems 1-3),* NASA RP 1376 Vol. 2, 85-119.

Suttles, J. T., Green, R. N., Minnis, P., Smith, G. L., Staylor, W. F., Wielicki, B. A., Walker, I. J., Young, D. F., Taylor, V. R., and Stowe, L. L. 1988*: Angular Radiation Models for Earth-Atmosphere System. Volume I: Shortwave Radiation.* NASA RP-1184.